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7.0 ECOLOGICAL EVALUATION

This Area III ecological evaluation identifies risks to ecological receptors from Raymark soil-waste/fill present in the Beacon Point Area (Area D) and the Elm Street Wetlands (Area E). It is based on ecological analyses conducted by SAIC (SAIC, 1998 and 1999a) and additional chemical data. The original ecological risk assessment (ERA) for the Raymark OU3 was performed by the National Oceanic and Atmospheric Administration (NOAA, 1998), but it did not include any analysis of Area III. The purpose of this ecological evaluation is to summarize and expand upon the assessments conducted by SAIC and to use the methods of NOAA to present a comprehensive evaluation of the risks to ecological receptors from Raymark soil-waste/fill wastes in Area III.

The NOAA ERA was performed for the environmental receptors associated with Ferry Creek and the Housatonic River. NOAA's analysis was limited to aquatic environments in the "upper reaches of Ferry Creek", "lower reaches of Ferry Creek", the Housatonic River at the mouth of Ferry Creek, and the wetland area south of the Housatonic Boat Club. The Housatonic River at the mouth of Ferry Creek, the lower reaches of Ferry Creek, and the wetland area south of the Housatonic Boat Club lie within Areas B and C.

The first SAIC study included sediment toxicity testing and chemical analyses of sediment and fish tissue within a study area in Stratford that includes Area D (SAIC, 1998). The purpose of this study was to discern which chemicals were most likely to be causing harm to the environment. The second SAIC study assessed ecological risk in Areas D and E using sediment toxicity testing and chemical analyses of sediment and mussel tissue (SAIC, 1999a).

The NOAA and SAIC studies focused on aquatic pathways and receptors; the primary ecological receptors considered were the aquatic biota and wildlife species that are linked to the aquatic habitat through the food chain. Appendix D contains the entire SAIC (1998, 1999a) reports that include toxicity, sediment chemistry, and biological tissue data, as well as a food chain risk analysis. The original ERA (NOAA, 1998) is also in Appendix D; it includes a glossary of terms used in this section but did not address Areas D and E. In addition to the SAIC investigations, the Area III ERA relies on surface water and sediment analytical data collected by various parties between 1993 and 1997. Only samples taken within the designated Area E (Figure 1-2) were used to characterize sediment contamination, while sediment data are available for other parts of the Elm Street Wetlands. For example, three of the four sediment toxicity samples taken in the wetland were outside Area E. Sediment contaminant data associated with these samples was used only to analyze the relationships between chemical concentrations and toxicity.

This evaluation focuses on Area III, that includes Areas D and E. Area A was assessed in a Final RI Report (TtNUS, 1999b) and Area II was assessed in a Draft RI Report (Areas B, C, and F) (TtNUS, 2000).

7.1 Site Description and Potential Receptors

This section presents the characteristics of Area III that are relevant to the ecological evaluation, and identifies the ecological receptors that are potentially exposed to contaminants in the environmental media in the area. A brief discussion of the nature and extent of contamination is included; a comprehensive discussion is presented in Section 4.0.

7.1.1 Study Area Description

Area III is part of what was once an extensive salt meadow marsh bordering the Housatonic River (B&RE, 1998). Extensive filling of the wetlands was performed to create the boat launch and its parking facilities (Area D), as well as the Stratford publicly-owned treatment works (POTW) that lies between the river and the Elm Street Wetlands (Area E). Areas D and E and the reference area are described in Section 1.3.7 and further defined below:

The ERA reference areas are locations where samples were taken assuming no contamination existed. The reference areas are called Nell's Island and Great Meadows. Nell's Island is a large salt meadow marsh located on the eastern shoreline of the Housatonic River. Great Meadows is also a large salt meadow marsh that is located on the southern end of Stratford bordering Long Island Sound. These ERA reference area were selected to be similar to the potentially impacted areas in terms of habitat, salinity, and sediment characteristics like grain size and organic carbon content. The vegetation marsh is primarily within the *Spartina alterniflora* and *Spartina patens*. Other marsh vegetation present includes *Iva frutescens,* *Distichlis spicata, Juncus gerardii, Limonium nashii, Salicornia europea,* and *Salsola kali.* These areas were sampled to represent reference chemical concentrations for comparison with potentially impacted areas. However, reference chemical concentrations may not indicate pristine background conditions, where no man-made influence is expected. This is the case because the study area, including the reference locations, is in an urban setting with many sources of environmental contaminants in addition to Raymark waste. Stratford is in the most densely populated part of the most populous county in Connecticut. The EPA has assessed the health of the Housatonic watershed as having "more serious problems," based mainly on fish advisories and lack of designated use attainment (http:\\www.epa.gov/iwi/hues/01100005/indicators/indindex.html). According to census figures, more people are employed in manufacturing in Fairfield County than any other business category. Manufacturers are more likely than most other businesses to contribute to water pollution. The study area is bordered by the Housatonic River, which has been contaminated by PCBs from historical discharges in Massachusetts, and by many sources on a tributary, the Naugatuck River. The confluence of the Housatonic and the Naugatuck is upstream of the study area. Water quality in the Naugatuck is so poor that it does not support designated uses from Waterbury to its confluence with the Housatonic. This is the longest reach of all Connecticut rivers that does not support designated uses. In addition to upstream point sources, local sources like boats and urban storm runoff are also likely to affect water and sediment quality in the study area.

- **Area D (Beacon Point Area)** is comprised of the wetlands in Area D that are separated into a northern and southern section by the boat launch area. The southern marsh section contains a drainage channel from the Stratford POTW. It encompasses undeveloped wetlands that are tidally influenced by the Housatonic River, a public boat launch area that EPA refers to as the Birdseye Boat Launch, and a dry dock area that EPA refers to as the Beacon Point Dry Dock. Area D covers approximately 20 acres, including approximately 3 acres of wetlands, 9 acres of open water, and the remaining 8 acres of manmade features (the public boat launch, the dry dock area, and an erosion barrier along the shoreline). The wetlands in Area D are separated into a northern and southern section by the boat launch area. Extensive filling has occurred to create the boat launch area, which is comprised of a large paved asphalt lot with dock structures extending into the river. The southern marsh section contains a drainage channel from the Stratford POTW. The dominant wetland system present in Area D has been classified as regularly flooded intertidal estuarine emergent (E2EMN). The wetland plant community in Area D is dominated by *Spartina alterniflora*, as may be expected under natural conditions in a low marsh. *Phragmites australis*, a reed that is nearly always associated with physical or hydrological disturbances in this region, is a minor component of the plant community. The *Phragmites* is only present along the upper edges of the marsh and adjacent uplands. The remaining portions of the open marshes in Area D are relatively undisturbed. However, because of the surrounding development and disturbances in and along the edges of the marshes, the wetland is, as a whole, considered "moderately to severely degraded" (B&RE, 1998). Upland grasses, *Phragmites, Rhus typina*, and lawn areas dominate uplands along the marsh banks.

- **Area E, Elm Street Wetlands** is comprised of the Elm Street Marsh that appears to be a fragment of the original marsh that is now surrounded by developed, filled land. Although the study area boundaries indicate only a small portion of the wetlands is under study, samples were taken throughout the wetland area. Although tidally influenced, the marsh is irregularly flooded. A small rip-rapped drainage channel runs along the northern edge of the wetland study area. Area E covers approximately 1 acre, which is entirely wetland. This wetland appears to be a fragment of an original salt marsh system that has been filled and developed. The dominant wetland system present in the study area has been classified as irregularly flooded intertidal estuarine emergent (E2EMP) that has been severely degraded (B&RE, 1998). Portions of the wetland are tidally influenced; generally only during spring tides. The former tidal creek that connected Area E to the southern section of Area D is now encased in at least 600 feet of pipe culvert. Tidal exchange appears restricted the marsh plant community is dominated by a monoculture of *Phragmites*. These conditions are very different from the high marsh habitat that would be expected in a natural situation of unrestricted tidal exchange. Wildlife use of the Elm Street Marsh is probably much reduced from conditions that existed before the surrounding marsh was filled and developed. Although the study area boundaries indicate only a small portion of the wetlands is under study; samples were taken throughout the wetland area. The most recent samples from 1999 (SAIC, 1999a) were taken within the Elm Street Marsh and are included in this ecological evaluation. However, these samples were taken outside the study area boundaries (Figure 1-2).

7.1.2 Water and Sediment Conditions

Field measurements of water temperature, pH, dissolved oxygen, salinity, and conductance were taken while sampling Area III surface water in 1994 and 1995. Salinity measurements in Area D ranged from 10 to 31 parts per thousand (ppt) and in Area E they ranged from 0 to 2 ppt. The average salinity of seawater is 35 ppt. The proximity of the Housatonic River to Area D is reflected in the higher salinity there, while restricted tidal influence apparently results in lower salinity in Area E.

Dissolved oxygen measurements in Area D ranged from 6.35 to 17.2 mg/L, taken at temperatures of 12.4 and 13.2 degrees C, respectively. The minimum was measured in November and a similar oxygen concentration of 6.4 mg/L was measured in August. The 6.35 mg/L value was about 60 percent of the concentration expected when water is saturated with dissolved oxygen, while the 17.2 mg/L value indicated supersaturation. In Area E, dissolved oxygen values ranged from 0.75 to 9.4 mg/L. The lowest reading was taken with a temperature of 20.9 degrees C, in August. Low oxygen conditions in Area E probably occur in areas shaded by dense growths of *Phragmites*, and where there is little water movement.

The range for pH measurements in Area D was 5.68 to 8.06 and in Area E it was 3.76 to 6.55. Seawater is more buffered than most freshwaters, with a pH of about 8.1. As with salinity, river influence can be seen in Area D and freshwater conditions are more apparent in Area E.

Three measurements were taken for evaluating sediment conditions: grain size, total organic carbon (TOC) content, and the concentrations of acid-volatile sulfides (AVS) and simultaneously extracted metals (SEM). Sediment grain size is related to water velocity; as velocity decreases, larger particles settle out. Therefore, grain size evaluates whether samples were taken in an area where fine particles (clays and silts) have settled. Many contaminants adhere to particle surfaces, so fine particles are likely to contain more contaminants per unit of mass. In general, sediment should have more than 50 percent fines to be considered a depositional area. Grain size at the Nell's Island reference location ranged from 50 to 75 percent fines (NOAA, 1998), while a single sample at the Great Meadows background location had 22 percent fines (SAIC, 1999a). In Area D, the range was 1.7 to 68.8

percent fines and in Area E it was 59.5 to 95.4 percent fines (SAIC, 1999a). The median value in Area D was 31 percent fines. The lower amount of fine material in Area D may be based on more water movement along the sediment surface, including tidal action, while the large proportion of fines in Area E may be due to the relative lack of surface water flow.

Organic compounds tend to adhere to organic matter on particle surfaces. TOC measurements are used to estimate how much of a compound may be adsorbed to the sediment. In general, higher TOC measurements indicate higher adsorption potential. Dissolved organics are considered more available to exposed organisms than adsorbed contaminants. Midpoint values for TOC were about 3, 8, and 4 percent for Area D, Area E, and the background locations, respectively (Table 7-1). There was an unusually high TOC concentration in Area D, 82.6 percent. However, Area D had only 5 values (15 percent) greater than the Area E median of 8.1 percent TOC. With its higher TOC values, Area E may have reduced availability of organic contaminants relative to Area D and background.

SEM-AVS has been related to the availability of bivalent metals in sediment pore water. If metals are more available to the biota, toxic effects are more likely to be seen. Sulfides will bind with cadmium, copper, lead, nickel, and zinc. These metal sulfide compounds will typically remain insoluble under reducing (anaerobic) conditions. This may decrease the amount of these toxic metals available to organisms, perhaps even under aerobic conditions. If the summed SEM minus AVS is greater than zero on a molar basis, the toxic metals may be bioavailable since there is insufficient sulfide to completely bind them. Other substances, like organic compounds, can also bind these metals. Therefore, when SEM-AVS is greater than zero, the metals may still not be available. SEM-AVS was greater than zero in four of six samples in Area D and two of four samples in Area E (Table 7-2). At the reference location two of three samples had SEM-AVS values greater than zero. Therefore, the toxic, bivalent metals may be available in Areas D and E, at about the same level as the background areas (SAIC, 1999a).

7.1.3 Habitats and Potentially Exposed Receptor Groups

The majority of Area III has been disturbed by commercial and residential development, including paving, building, and dredging activities. This has impacted the wetland areas and associated habitats. In impacted areas that remain wetlands, such as Area E, *Phragmites* often becomes dominant and biotic diversity is low. During the wetland evaluation, only the red-winged blackbird and the invasive plant species *Phragmites* and purple loosestrife were observed in Area E (B&RE, 1998). In Area D *Spartina alterniflora* dominated the low marsh community that comprises this area. Animal species seen included the mute swan, mallard, and herring gull, and the invertebrates rough periwinkle and ribbed mussel. Potentially, the lower marsh areas and creek banks of Area D would also have blue crab, fiddler crab, eastern oyster, and soft and hardshell clams (NOAA, 1998). Dominant fish species in the tidal channels of Area D would include Atlantic menhaden, bay anchovy, black seabass, striped killifish, mummichog, Atlantic and inland silversides, summer and windowpane flounder, and spotted hake. Area E would be expected to have few, if any, of the aquatic species mentioned for Area D. This is based on its separation from Area D, restricted tidal exchange, and irregular flooding.

Some 53 species of fish and 11 invertebrate species are expected to use the Housatonic for spawning, adult forage, or as a nursery ground for juveniles (NOAA, 1998). Recreational fish and invertebrate species include Atlantic menhaden, black sea bass, bluefish, four species of flounder, American eel, striped bass, white perch, and the blue crab. The American eel and the eastern oyster are caught commercially in this area. An important commercial larval bed for eastern oyster cultivation in the Housatonic River is present near the mouth of Ferry Creek. Of all the native threatened or endangered species, the Atlantic sturgeon is likely to be found in the Housatonic, and bald eagles and peregrine falcons may use the area while in transit.

7.2 Routes of Exposure

The ERA focused on the effect of chemical contamination, from Raymark soil-waste/fills originating at the Raymark Facility, to ecological receptors in Area III. Extensive sampling indicated the presence of Raymark soil-waste/fill within Area III. This waste contained varying amounts of contaminants including asbestos, PCBs, copper, and lead.

Ecological receptors are exposed to contaminants through several routes. These pathways of contaminant movement and contaminant entry to ecological receptors are diagrammed in Figure 7-2. Aquatic organisms can take up toxicants directly from contact with water or sediment. Terrestrial organisms can also take up contaminants from direct contact with contaminated soil, water, and sediment. Animals can ingest contaminants with surface water, soil, or food. Inhalation and uptake through foliage are also potential routes of exposure for terrestrial life, but they were not considered in the NOAA ERA, which focused on aquatic pathways and receptors (NOAA, 1998). The SAIC (1999a) risk assessment presents more details of aquatic exposure pathways.

Waste from the Raymark Facility is most strongly associated with sediments in Ferry Creek and fill material in the marsh or former marsh within the areas of concern. Therefore, an important pathway is direct exposure to waste in sediment, especially for ecological receptors that inhabit sediments. Also, if there are contaminants that accumulate in aquatic food chains, the food-chain pathway is important for larger animals that feed on sediment-dwelling organisms.

The reduced biotic diversity of Area E indicates that some pathways described above and present in Area D, may not be significant in Area E. Based on field conditions and informal surveys, significant populations of benthic macroinvertebrates were not expected in Area E. With important groups like oysters, crabs, and mussels unlikely to occur there, it is also unlikely that significant exposure through the food chain, as estimated for Area D, would result. Therefore, no tissue sampling was performed in Area E. Although this is technically a data gap, it is justified as a realistic reflection of the current value of this wetland.

7.3 Identification of Contaminants of Concern

Contaminants of concern (COCs) were selected following review of chemical concentration data for surface water, sediment, and the tissues of aquatic organisms. Soil and groundwater data were not evaluated in the ERA prepared by NOAA. Selection of the COCs involved comparing measured concentrations of contaminants to screening values. Screening values were the effects of range-low (ERL) concentrations in sediment (Long & Morgan, 1990). Dioxin and furan concentrations were expressed as TCDD TEQ concentrations and compared to a TCDD screening value for sediment. If no screening values were available, then the contaminant was included as a COC if it was detected in fish or shellfish tissue from historic samples. COC selection was done in the screening-level risk assessment (EVS, 1995); and the COC list was not changed in the baseline ERA (NOAA, 1998).

The COCs are listed on Table 7-3; toxic effects are described in the NOAA and SAIC ERAs in Appendix D. Many of the COCs are PAHs; these are components of petroleum-based fuels and lubricants. Dioxins and furans are COCs; these are byproducts of the manufacture of, or the incomplete combustion of, chlorinated compounds such as PCBs. Elevated levels of PAHs, PCBs, and dioxins/furans in environmental samples have been associated with waste from Raymark. The COC list includes several metals, and metals were used in manufacturing processes at Raymark. Pesticides may have been used for pest control at the Raymark Facility.

All of the COCs may cause harm to sediment-dwelling organisms. Mercury, dioxins, pesticides and PCBs can accumulate or even magnify in food chains, so they are of concern for animals that may prey on organisms living in the sediment.

SAIC (1999) independently selected sediment COCs based on sampling performed in 1999 at Areas C, D, E, and F. Some individual organic COCs differed from those listed in the NOAA ERA, but each of the following groups were represented: metals, PAHs, PCBs, dioxin/furans, and pesticides. SAIC eliminated arsenic and silver based on a comparison to background concentrations. To remain consistent with the previous ERA and RI reports, the original COC list (Table 7-3) is retained, and total PAHs, total PCBs, and total dioxin equivalents are used to estimate risk for Area III.

7.4 Selection of Ecological Endpoints

"Ecological endpoints" refers to setting goals within the risk assessment and addressing how the goals will be met. Goals for the assessment, or assessment endpoints, are:

- survival, growth, and reproduction of the indigenous benthic community (both infauna and epibenthic)
- survival, growth, and reproduction of the oyster population
- protection of fish population from adverse reproductive effects and mortality

- protection of bird population from adverse reproductive effects and mortality
- protection of mammal population from adverse reproductive effects and mortality

To see if the goals are met, measurements are taken that relate to the assessment endpoints, as shown in Table 7-4. Sediment contaminant concentrations were measured and compared to published concentrations representing acceptable risk to benthic communities. Sediment toxicity tests were performed on amphipods and the larvae of bivalve mollusks and compared to reference samples tested at the same time. Contaminant concentrations in surface water were compared to criteria designed to protect aquatic life, including fish. Finally, contaminant levels in fish and invertebrate tissue were measured and used to estimate risks to the fish and invertebrate themselves and the predatory birds and mammals that eat the tissue.

7.5 Selection of Indicator Species

Numerous species of aquatic invertebrates, fish, mammals, and birds could be exposed to the COCs within the Area III study area. The selection of representative species for the Area III study area was based on relevance to the assessment endpoints, life history, and ecological niche within the study area. The selected receptors are: benthic infauna, fiddler crab, eastern oyster, mummichog, black-crowned night heron, and the raccoon.

7.6 Ecological Effects

This section discusses the potential adverse effects of contaminants on the indicator species, based on the measurements described above.

7.6.1 Chemistry

The nature and extent of contamination in surface water and sediment is used to estimate the potential for risk to ecological receptors. Risk is estimated by comparing surface water concentrations to ambient water quality criteria, and by comparing sediment concentrations to threshold effects levels.

7.6.1.1 Surface Water

Organic compounds and metals were measured in six surface water samples in Area D, five in Area E, and at seven background locations. In Area III, Aroclors (PCBs) and several metals were detected at levels exceeding water quality criteria. PCBs were measured in four samples from Area E (Table 7-5). The water quality criterion for PCBs, is based on estimated food-chain effects, not direct toxicity to aquatic life. Secondary Chronic Values (SCVs) (ORNL, 1996) are protective of aquatic life; the freshwater SCV for total PCBs is 0.14 µg/L. Therefore, the PCB concentrations in Area E may be directly harmful. Food chain effects are discussed in Section 7.6.3.

Cadmium, chromium, copper, lead, nickel, silver, and zinc in surface water were at concentrations greater than at least one of their ambient water quality criteria. As shown on Table 7-5, the freshwater criteria for cadmium, trivalent chromium, copper, lead, nickel and zinc are hardness-based, and a 100 mg/l hardness value was assumed (NOAA, 1998). Area D has more marine than freshwater influence, so the marine values are more applicable. This indicates that there is potential risk to aquatic life from copper, lead, and zinc in Area D. The applicability of water quality criteria in Area E is uncertain, because its classification as marine or freshwater is moot and it lacks open-water habitat. Being conservative, there is potential risk in Area E from exposure to cadmium, chromium, copper, lead, nickel, silver, and zinc in surface water.

7.6.1.2 Sediment

Sediment contaminants were measured in a maximum of 62 samples (not every sample was analyzed for every contaminant) taken in Area D, 12 in Area E, and six at reference locations. As in the NOAA (1998) ERA, threshold effect levels (MacDonald et al., 1996) were used as screening values for sediment concentrations. These are guidelines below which adverse biological effects are not expected to occur. Screening was performed by dividing the mean contaminant concentration for each area by the threshold effect level (TEL) (Table 7-6). The resulting hazard quotient (HQ_{TEL}), if less than 1, suggests that adverse biological impacts are unlikely.

Except for cadmium, the HQ_{TEL} for sediment metal COCs were 1 or greater in both Areas D and E (Table 7-6). Similarly, HQ_{TEL} values for the reference location were above 1 for all of the COC metals except arsenic. Silver was not detected in the reference location. Copper and lead HQ_{TEL} were the highest values among the sediment metals, with maximums of 45.6 for copper and 22.8 for lead, both in Area D. For comparison, the reference area HQ_{TEL} values for copper and lead were 34.9 and 3.2, respectively. (Most of the Nell's Island reference location chemical data have been excluded from the working Raymark database because many of the concentrations are thought to be too high for background.). Area E copper HQ_{TEL} levels was below the reference area, while the lead HQ_{TEL} value in Area E, 5.6, was higher than the reference. In Area D, arsenic, cadmium, lead, nickel, and zinc HQ_{TEL} levels were more than twice the respective background value. None of the Area E HQ_{TEL} values for metals were more than twice background.

Unlike the metals, sediment HQ_{TEL} values for most organic COCs were highest in Area E, the Elm Street wetlands (Table 7-6). The HQ_{TEL} value for PCBs in Area E, 740.7, was the highest of any chemical in Area III. Area E HQ_{TEL} values also were greater than 10 for DDE (15.5) and PAHs (11.3). Area D HQ_{TEL} levels were the highest for DDD (9.8) and dioxins (28). The reference area HQ_{TEL} values were lower than Areas D and E for all of the organic COCs except PAHs.

In summary, sediment screening results indicate potential risk from exposure to all of the COCs selected in the preliminary Ecological Risk Assessment (EVS, 1995). SAIC (1999a) obtained similar results. PCBs, copper, dioxins, lead, and pesticides appear to contribute most to potential risk.

7.6.2 Contaminant Residue in Organisms

Contaminant concentrations in tissue can be used to evaluate how much exposure to toxicants has occurred, the potential for harm to organisms containing the residue, and what exposures may result from consuming the tissue. Tissues were analyzed from ribbed mussels taken in Area D. The restricted hydrological connection to the Housatonic River and the presence of a monoculture of *Phragmites* in Area E prevents significant exposure for the indicator species and the groups they represent. Therefore, no tissue samples were taken in Area E.

No reference area data are available for the ribbed mussel contaminant levels. Therefore, assessment of the extent of mussel exposure relative to background is not possible. SAIC (1999a) provided guidelines for invertebrate tissue concentrations that were lowest effect levels for the invertebrates themselves. Four of the five mussel tissue samples in Area D (Table 7-7) exceeded the copper guideline (17.8 mg/kg wet weight). Although no mussel samples were collected in the reference areas, the copper concentration for one invertebrate (fiddler crab) sample from Nell's Island also exceed the guideline. Mussel tissue concentrations from Area D did not exceed tissue guidelines for cadmium, chromium, mercury, nickel, zinc, DDT, PCBs, and PAHs. The potential effect of these tissue contaminant levels on predators is discussed in the next section.

7.6.3 Effects on Wildlife

Residue levels in ribbed mussels were used to estimate effects on the raccoon and the black-crowned night heron. Heron and raccoon were assumed to feed 100 percent of the time in Area D, consuming mussels and incidentally, sediment. In the reference location, the heron and raccoon were assumed to feed on fiddler crabs, because this is the only invertebrate species sampled in the reference area. Because of the depauperate habitat, significant wildlife exposure is not considered likely in Area E. (SAIC [1999a] estimated wildlife risk in Area E from the 1999 sediment data, and found that one of four sediment samples posed potential risk to the heron and raccoon from mercury and PCB exposure.)

The food chain analysis consisted of estimating doses from feeding and drinking surface water, summing the doses, and comparing them to threshold doses from the toxicological literature using the quotient method; the approach to the food chain analysis was based on that of the ERA (NOAA, 1998), as modified by SAIC (1999a and 1999b). Quotients were obtained by dividing the dose for each contaminant by the toxicity reference value, a no-observed-effect level (NOAEL). Modifications included the addition of the raccoon as an indicator species and the assumption that sampled prey items composed 100 percent of the diet. Although SAIC (1999a) performed a food chain analysis for Area D, the data were limited to contaminant concentrations in sediment and mussels collected in 1999. The present analysis combines previous sediment and water quality data with the 1999 information. Tables showing the estimates, together with their hazard quotients, are included in Appendix D, following the NOAA and SAIC documents.

Two sets of contaminant concentrations were used in the food chain analysis, maximums and averages. Maximum concentrations indicated potential risk (hazard quotient greater than one) for the heron and raccoon in both Area D and the reference area (Table 7-8). Arsenic, chromium, copper, lead, mercury, zinc, DDD, DDT, and PCBs were associated with this risk. The highest quotients, up to 22, were seen for lead and arsenic. Both the heron and raccoon had potential risk based on exposure to lead, mercury, and PCBs. The heron also has potential risk from chromium, zinc, DDD, and DDT, while the raccoon has potential risk from arsenic and copper. Most of the potential risks from chromium, copper, lead, zinc, and PCB were based on incidental ingestion of sediment, while arsenic, mercury, and DDT risks were mainly from contaminated prey.

Fewer risks resulted from using average contaminant concentrations in the food chain exposure analysis (Table 7-9). Arsenic may pose potential risk to the raccoon in Area D (HQ = 4.46) and in the reference area (HQ = 2.02), mainly due to arsenic levels in mussels in Area D and crabs in the reference area. The HQ of 4.46 for the raccoon exposed to arsenic was the highest risk level calculated for average contaminant concentrations. Potential risks for the heron from lead (HQ = 1.01), mercury (HQ = 1.05), and zinc (HQ = 1.87) occurred in Area D. Most of this risk was from lead in sediment and mercury and zinc in mussels. The potential risk levels are generally low, especially considering that "no effect" levels were used for toxicity values. Lowest observed adverse effect levels (LOAELs) tend to be two to ten times higher than no observed adverse effect levels (NOAELs) and hazard quotients for metals would be lower, most below one, if LOAELs were used for metals.

The exposure information and estimated risk levels for wildlife and invertebrates described so far indicate some differences in the chemicals with the highest ranks in each case. PCBs, copper, and dioxins had the highest hazard quotients for sediment invertebrates, meaning that they had the highest concentrations relative to sediment concentration guidelines (Table 7-6). This indicates high exposure levels for invertebrates, and for wildlife through incidental ingestion of sediment. However, estimated risks to invertebrates from contaminant concentrations in their tissue and overall risks to wildlife from ingesting this tissue together with sediment, are mainly from metals. This indicates that organic contaminants like dioxin and PCBs may not be very available for uptake by the biota.

The bioavailability of organic compounds can be assessed using data at the sampling and subarea (Areas B, C, D and F) levels. Consideration of areas beyond Area III is needed to understand potential relationships between contaminant concentrations in sediment and tissue. For total PCBs, co-located mussel and sediment samples in Areas C and D had roughly similar concentrations, and mean biota-sediment accumulation factors (BSAFs) from these samples were similar to published values (SAIC, 1999). However, the maximum sediment total PCB concentration in these samples was 188 μg/kg; this value is more than an order of magnitude less than the average total PCB concentrations in Areas C (2,700 μg/kg) and D (6,900 μg/kg). It would be inappropriate to apply BSAFs to much higher sediment concentrations than those from which they were derived. Additional tissue data are available for fish, crabs, and molluscs in Area B, crabs in Area C, and fish in Area F (Tables 7-7 and 7-8). The maximum tissue concentrations in Areas B and C were found in fiddler crabs, at 180 and 1800 μg/kg, respectively. The highest tissue concentration in Area F was 536 μg/kg and in the reference area it was 510 μg/kg. The average total PCB concentrations in each subarea were at least 1,100 μg/kg; the average in the reference area was 1.1 μg/kg. Therefore, the sediment and tissue concentrations of PCBs do not appear to vary together at the subarea level. This may mean that PCBs are taken up less as their concentrations increase, or that exposure is not occurring at higher concentrations. The latter possibility could come about if the more highly contaminated sediments are toxic or are avoided by the biota.

7.6.4 Toxicity Testing

Two investigations of sediment toxicity were conducted in Area III from 1997 to 1999, both using a 10-day amphipod survival test. Details of the test procedures are provided in the SAIC (1998, 1999a) reports, contained in Appendix D. Toxicity was determined by statistical comparisons between laboratory control sediments, sediments from Area III, and reference areas.

The only point sampled in Area D in 1997, BN03, was not toxic to amphipods (Table 7-10). In 1999, all six of the sediment samples taken in Area D were toxic: sample D-1 had borderline toxicity (79.3 percent survival), samples D-4 and D-5 had low toxicity (60 to 80 percent survival), samples D-2 and D-3 had intermediate toxicity (20 to 60 percent survival), and sample D-6 had high toxicity (3.3 percent survival). Sample location BN03 was within 50 feet of location D-3, indicating that results varied from 87 to 50percent survival within a relatively small distance and time span.

All of the toxicity data for Area E pertain to sediment samples taken in 1999. All four samples were toxic to amphipods: samples E-1, E-2, and E-3 had low toxicity (60 to 80 percent survival) while sample E-4 had intermediate toxicity (20 to 60 percent survival) (SAIC, 1999a).

SAIC (1998) identified copper as the primary COC contributing to sediment toxicity for the testing done in 1997. Arsenic, zinc, PCBs, and dioxins were also identified as potentially contributing to effects observed during testing. In the 1999 testing, exposure-response relationships between sediment contaminants and toxicity test results were not apparent (SAIC, 1999a).

In addition to the SAIC testing in 1997 and 1999, NOAA (1998) reported amphipod test results from sampling done in 1995 in the Raymark study area. Data combined from the three amphipod test events were reviewed for general relationships with sediment chemistry. The first step in this analysis was to investigate correlation among the variables (Appendix D, Table 18). In general, the COC concentrations were collinear, meaning they varied together, especially the metals. TOC, fines (silt + clay fraction), and SEM-AVS were not correlated with contaminant concentrations. In a multiple regression analysis of these data, copper was the best predictor of amphipod survival in the combined data set ($p = 0.004$, $r^2 = 0.18$). Although significant, the relationship between copper and amphipod survival explains only 18 percent of the variability in the data. The extent of this variability is apparent in a scatter plot (Figure 7-2).

Lead, zinc, and total TCDD equivalents (dioxins) were significantly (95 percent confidence level) related to sediment toxicity in the combined data set. Copper and lead concentrations in sediment porewater were not related to sediment toxicity, nor were porewater concentrations of the other metals (arsenic and chromium) that were evaluated.

Another approach to investigating which chemicals are more likely to be causing sediment toxicity is to compare sediment concentrations to guideline values, as was done in Table 7-6. The TELs used in this table were designed to be protective of sediment-dwelling organisms. The highest hazard quotients in Area III were associated with PCBs, copper, and dioxins in decreasing order. Copper has the best relationship with sediment toxicity in tested sediment, as just described. Dioxins also have a significant relationship with sediment toxicity when using all toxicity testing data ($p = 0.014$, $r^2 = 0.14$). PCBs, however, would only have a significant relationship with toxicity for all the data if the confidence level was less than 95 percent ($p = 0.066$, $r^2 = 0.08$). In a stepwise multiple regression analysis done by area, total PCB is the best predictor in Area A3 ($p = 0.069$, $r^2 = 0.32$). The only other noteworthy result from testing by area was that copper was the best predictor in Area D ($p = 0.005$, $r^2 = 0.89$).

Along these same lines, the frequency with which guidelines are exceeded may be used to predict toxicity in sediments. Long et al. (1998) showed that the number of ER-Ms exceeded in a sample predicts acute toxicity in marine and estuarine sediments. This approach was attempted using the combined amphipod data set for Raymark. Some decrease in survival rate could be seen as the number of exceeded ER-Ms increased, but variability was high and the relationship was not significant. Another set of guidelines that was available for testing was the criteria for classification as Raymark waste used for soil removal actions in the past. The criteria included meeting two of the following:

- 400 mg/kg lead
- 1 mg/kg PCB
- 1 percent asbestos

Because asbestos was not evaluated for ecological toxicity, samples meeting the lead and PCB levels were considered "Raymark waste." Out of a total of 43 amphipod test samples, 33 were toxic (77 percent). Twelve of the 43 test samples met the Raywaste criteria and 10 were toxic (83 percent). Use of the Raywaste criteria does not appear to significantly increase the prediction of toxicity among these samples.

However even if it is variable, the relationship between copper and survival rate may be useful for risk management. The highest copper concentration associated with the lack of toxicity (survival of 80 percent or more) is 1350 mg/kg. The lowest copper concentration associated with toxicity is 22.6 mg/kg. These two concentrations define the range for a suitable, protective guideline value for copper (Figure 7-2). The median copper concentration in this range is 278 mg/kg; this value is associated with a survival rate of 68.5 percent. (Median survival in the range is 70.7 percent.) SAIC (1998) found that copper concentrations were more closely associated with toxicity in sediment pore water than other contaminants. SAIC's PRG range for copper in bulk sediment was 329 mg/kg to 8700 mg/kg. This range overlaps the range suggested by the combined amphipod test results from 329 mg/kg to 1350 mg/kg.

The usefulness of copper as a surrogate for other COCs depends on how well concentrations of the other COCs are related to copper concentrations. Cadmium, chromium, copper, lead, nickel, and zinc correlate significantly with all of the COCs, when all of the surface sediment data are analyzed (Table 4-14). Nickel and copper have the highest correlation coefficients, ranging from 0.40 to 0.85 for nickel and from 0.39 to 0.87 for copper. Although these coefficients are all statistically significant, the lower coefficients (0.39 and 0.40) show that the relationships explain less than 20 percent of the variation in the data. The following table shows the strengths of the relationships between copper and the other COCs.

COC	Relationship With Copper - Surface Sediment	
	Correlation Coefficient	Percent Variation Explained
Arsenic	0.54	30
Cadmium	0.59	35
Chromium	0.79	62
Lead	0.87	75
Mercury	0.39	16
Nickel	0.83	69
Silver	0.43	19
Zinc	0.81	65
Total PAHs	0.47	22
Total PCBs	0.51	26
2,3,7,8-TCDD TEQ	0.67	45

When correlations are calculated by area, relationships between copper and the other COCs tend to be stronger in Areas D and E, when they are significant (Table 4-14). However, statistically significant relationships are lacking (at $p < 0.005$) between copper and mercury, total PAHs, total PCBs, and dioxins in Area D and between copper and cadmium, total PAHs, and dioxins in Area E. A correlation coefficient of 0.7 means that about 50 percent of the variation in the paired data are explained by the relationship between the concentrations of the paired chemicals. This value was used as a guideline for the degree of uncertainty in using copper as a surrogate for each COC.

COC	Uncertainty With Use Of Copper As Surrogate	
	Area D	**Area E**
Arsenic	low	low
Cadmium	high	high
Chromium	high	low
Lead	low	low
Mercury	high	low
Nickel	low	low
Silver	high	low
Zinc	low	low
Total PAHs	high	high
Total PCBs	high	low
2,3,7,8-TCDD TEQ	high	high

7.7 Summary

The ecological investigations assessed the risk to ecological receptors from Raymark soil-waste, and will support the development and evaluation of remedial alternatives for the Feasibility Study. The results from these evaluations are summarized in Table 7-11 and below.

- Concentrations of cadmium, chromium, copper, lead, nickel, silver, zinc, and PCBs in surface water at Area III may be harmful to fish and other forms of aquatic life.

- Sediment levels of PCBs, copper, dioxins, lead, and pesticides where the principal contributor most to potential risk for sediment-dwelling organisms. Although these contaminants are present in the sediment in both areas, the highest average concentrations of PCBs and pesticides occur in Area E, while the highest values for copper, dioxins, and lead occur in Area D.

- Tissue concentrations of copper indicate potential risk to invertebrates in Area D.

- Sediments in Area D had low toxicity to amphipods in six of seven tests, with three samples presenting moderate or severe toxicity. The lowest survival rate for amphipods, 3.3 percent, occurred in a sample from Area D. All other survival rates were near 50 percent or higher.

- Sediments in Area E had at least low toxicity to amphipods in each of four tests, with one sample having moderate toxicity.

- Potential risk exists for wildlife under average exposure conditions in Area III. Arsenic occurred in the raccoon's diet at potentially harmful levels in Area D. Lead, mercury, and zinc posed potential risk to the heron, also in Area D. Although habitat quality is low, there may be risks to wildlife from mercury and PCB exposure in Area E. Use of LOAELs and less conservative assumptions about wildlife use of contaminated habitat would lower the risks to acceptable levels.

7.8 Uncertainties

A brief discussion of uncertainties associated with the ecological assessment will help place the results in perspective. More detailed discussions are part of the NOAA (1998) and SAIC (1999a) risk assessments in Appendix D. There are two major uncertainties associated with the ecological evaluations: 1) uncertainties related to measurements; and 2) uncertainties related to the availability of information.

Measurement uncertainties include the adequacy of the study design. Uncertainty from the study design includes such issues as whether enough samples were taken, suitability of the testing procedures, and the appropriateness of the reference areas. It is uncertain whether or not the findings would change significantly if more samples were taken or different procedures used. Unfortunately, investigating the efficacy of the study design requires the time and expense of multiple studies. The reference areas require more discussion, however, because they had some contamination.

Reference area contamination is an important source of uncertainty for applying the results of the risk assessment to management decision-making. Some contaminants, such as copper, had high sediment and tissue concentrations in the reference locations. These concentrations were high enough to be considered unlikely for natural background conditions. However, the study area is in an urban environment where there are many sources of contamination in addition to Raymark waste. Therefore, it may be appropriate to consider the effects of other sources in managing the ecological risk from Raymark waste in Area III.

Other sources of measurement uncertainly include the variability due to sampling and analysis, and errors in data handling and reporting. For example, sampling variability associated with chemical concentration in sediments tends to be high. There is also uncertainty associated with the co-occurrence of elevated contaminant concentrations and biological effects. Because many contaminants vary in concentration together, it is difficult to establish a cause-and-effect relationship for particular contaminants.

Uncertainty due to the availability of information is often considerable. To save costs and time, surrogates for large groups of organisms are used for toxicity testing and estimating the effects of contaminants in the food web. Although the species used in toxicity tests are typically sensitive to contaminants, there is uncertainty in relating the sensitivity of test organisms under laboratory conditions to the larger community under natural conditions. There are also uncertainties in toxicity testing that result from many potential chemical and physical interactions. Organic carbon content, grain size, pH, oxidation-reduction potential, naturally occurring toxicants (e.g., ammonia and hydrogen sulfide), and many other sediment properties can affect its perceived toxicity. Such factors result in the wide variation often seen when toxicity test results are compiled.

Risk to invertebrates was estimated using tissue concentrations in ribbed mussels to predict toxic effects. The levels of contaminants in species that were not sampled are uncertain, and the strengths of relationships between tissue concentrations and toxic effects in the animal with the body burden are unknown.

The food web modeling for wildlife exposure and the subsequent estimation of toxic effects have many sources of uncertainty. An important source is the number of receptors and contaminant exposure pathways that were not evaluated. Many more animals inhabit the area than could be analyzed for potential risk, and differences among them in feeding habits and other factors may be expected to produce a wide range of exposures. Other uncertainty sources in the food web analysis include the assumptions made about feeding the potential for multiple contaminants to have synergistic or antagonistic effects, and the application of toxicity data from dissimilar species tested in laboratories. Assumptions made about feeding include the fractions of ingested contaminants that are bioavailable and the amount of various food items in the diet. The raccoon and the black-crowned night heron were assumed to feed solely on items from the study area, which is smaller than their home ranges. Also, raccoons are omnivorous and will likely take considerable food from terrestrial sources. Although the terrestrial food web was not investigated, calculated risk levels were probably increased by conservative feeding assumptions.

7.9 Conclusions and Recommendations

Toxicity risks are evident for sediment-dwelling organisms living in the vicinity of soil-waste/fills from the Raymark Facility. Generally low to moderate levels of biological effects were seen in Areas D and E. Risk for sediment-dwellers ranged from low to high in Area D, depending on location. This corresponds to the pattern of sediment contamination in Area D, which varies from low concentrations to some of the highest in the Raymark study area.

Because of the high risk that can occur in parts of Area D, the amelioration of these risks should be considered in a feasibility study. Although risk levels are more moderate and the habitat quality is lower, contaminant concentrations in some parts of Area E are high enough to also be considered in feasibility study. Protection of sediment-dwelling organisms, which appear to be at most risk, should be given most consideration among environmental receptors. If measures are taken to protect these organisms, they will likely lessen the risk potential for others.

8.0 SUMMARY AND CONCLUSIONS

The Raymark OU3 Area III study area (see Figure 1-2) consists of properties in and around lower Ferry Creek, the wetlands surrounding the Housatonic Boat Club and Selby Pond and its surrounding wetlands. It is located within the 100-year floodplain in the Housatonic River Basin, a tidally influenced system. The study area covers approximately 21 acres, which includes 13 acres of wetlands and/or open water, with the remaining acres encompassing commercial properties. The Area III topography is relatively flat, with gentle slopes to several wetlands and open water of the Housatonic River.

This Draft Area III RI report summarizes the activities performed under various investigation programs by federal, state, and private contractors. An enormous amount of data has been collected (Appendix B). Investigations were performed by more than 30 entities over a 7-year period (1992-1999). Biota, surface water, groundwater, air, sediment, and soil samples have been collected. The media under discussion for Area III include biota, surface water, sediments, and soils. Groundwater was not included within the scope of this Area III RI. No air samples are included in this study because air samples were only collected for worker health and safety purposes.

The objectives of this Area III RI are to:

- Serve as the mechanism for compiling and evaluating all available data needed to characterize the Area III study area conditions,
- To determine the nature and extent of contamination within the biota populations, in the surface water, sediment, and soil; and contaminant movement on Area III properties impacted by waste from the Raymark Facility,
- Assess the risks to human health and the ecological receptors within the Area III study area, and
- Serve as the data resource for developing, screening, and evaluating a potential range of alternative remedial actions that addresses the contamination within Area III.

As detailed in Section 2.0, the Area III study area is located south of the former Raymark Facility. This area was targeted for study because waste from the Raymark Facility was disposed of on or near the properties. Area III is impacted by the Raymark waste through either direct disposal of Raymark soil-waste/fill or deposition of Raymark-related contaminants via surface water flow, storm runoff, or other means, as discussed in Section 5.0.

8.1 Nature and Extent of Contamination Summary

The Raymark Facility waste, referred to in this document as Raymark soil-waste/fill, contains volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), dioxins and furans, metals (lead, copper, and barium), and asbestos. This Raymark soil-waste/fill was disposed of as fill material throughout Area III. Additionally, process water and runoff from the Raymark Facility containing these contaminants were directly discharged to Ferry Creek, which flows to the Housatonic River. Area D is comprised of wetlands/marsh along the Housatonic River. Soils, surface water, sediments, and biota throughout Area III have been contaminated from the Raymark Facility discharges, from direct deposition of Raymark soil-waste/fill, and from contaminant transport from areas that have received Raymark soil-waste/fill as fill. The pattern of contamination within Area III indicates various disposal practices. The extent of contamination by medium and area is summarized below and on Table 8-1.

8.1.1 Nature and Extent of Contamination within Area III

The contamination in Area III is in the soils, surface water, sediments, and biota. This contamination is the result of waste depositions as fill on properties in and around Area III and from transport of waste directly from the facility or from these deposit areas.

The fill that was investigated in Area III is a mixture of natural and man-made materials. Natural fill is made of clay, silt, sand, and gravel. Man-made materials consist of asphalt, metal, brick, glass, and other miscellaneous man-made materials, including manufacturing debris.

The field investigations have revealed that contaminants of Raymark soil-waste/fill are present in soils and sediments, at both the surface and subsurface in the Ferry Creek channel, Housatonic River, Selby Pond the adjacent wetlands for each of these water bodies, and in the surface waters of Ferry Creek. See Table 8-1 for a summary of contaminants.

8.1.2 Volatile Organic Compounds (VOCs)

VOCs were infrequently identified contaminants within Area III (Areas D and E).

8.1.2.1 Nature of VOC Contamination

Three primary groups of VOCs were detected within Area III: chlorinated hydrocarbons, aromatic hydrocarbons, and ketones. Many of these are commonly used in industrial processes; they are also constituents of gasoline and petroleum fuels.

8.1.2.2 Extent of VOC Contamination

- Area D – Infrequent detections in sediments, surface and subsurface soils, and surface water. VOCs were not analyzed for in the biota.

- Area E – Infrequent detections in sediments, and surface water. Soil samples were not analyzed for VOCs. No biota samples were collected in this area.

8.1.3 Semivolatile Organic Compounds (SVOCs)

SVOCs were identified as contaminants in both sections of Area III (Areas D and E).

8.1.3.1 Nature of SVOC Contamination

Three primary groups of SVOCs were detected within Area III: phenolic compounds, polynuclear aromatic hydrocarbons (PAHs), and phthalates. Many of these contaminants are common constituents of various industrial products, used in the manufacture of friction materials (such as those made at Raymark), and are associated with fuels, coal, and petroleum products. Phthalates were used as plasticizers in the manufacture of synthetic products (such as the synthetic resins made at Raymark).

8.1.3.2 Extent of SVOC Contamination

- Area D – SVOCs were frequently detected in both surficial and subsurface sediments, surface and subsurface soils, and the biota. SVOCs were only detected in one surface soils sample or in surface waters.

- Area E – SVOCs were frequently detected in surface sediments. SVOCs were infrequently detected in the subsurface sediments, surface waters, and soils. No biota samples were taken in this area.

8.1.4 Pesticides

Pesticides were identified contaminants in both sections of Area III (Areas D and E).

8.1.4.1 Nature of Pesticide Contamination

Pesticides are assumed to have been used at the Raymark Facility, as indicated by pest control practices common in manufacturing plants. Pesticides were detected in residential soil-waste stored at the Raymark Facility.

8.1.4.2 Extent of Pesticide Contamination

- Area D - Pesticides were frequently detected in surficial and subsurface sediments. Pesticides were infrequently detected in surface waters, soils, and biota.

- Area E – Pesticides were frequently detected in subsurface sediments. Detections of pesticides were infrequent in surface sediments, surface water, and soils. Biota samples were not taken in this area.

8.1.5 Polychlorinated Biphenyls (PCBs)

PCBs were identified contaminants in both sections of Area III (Areas D and E).

8.1.5.1 Nature of PCB Contamination

The PCBs identified within Area III consisted primarily of Aroclor 1262 and Aroclor 1268, (the two types of PCBs known to be used at the Raymark Facility). PCBs are typically used as plasticizers in the manufacture of brake linings, rubber gaskets, and synthetic resins (such as were made at Raymark).

8.1.5.2 Extent of PCB Contamination

- Area D – PCBs were infrequently detected in the biota and in both surficial and subsurface sediments and soils. No PCBs were detected in surface waters.

- Area E – PCBs were frequently detected in both surficial and subsurface sediments. PCBs were infrequently detected in surface water and soil samples. No biota samples were collected in this area.

8.1.6 Dioxins/Furans

Dioxin/furans were identified contaminants in both sections of Area III (Areas D and E).

8.1.6.1 Nature of Dioxin/furan Contamination

Dioxins/furans are not used in manufacturing processes; they are formed during the production of chlorinated compounds (such as pesticides or PCBs) or from incomplete combustion of chlorinated compounds. Dioxins/furans were detected in samples collected from Raymark soil-waste/fill at the former Raymark facility.

8.1.6.2 Extent of Dioxin/furan Contamination

- Area D – Dioxins/furans were infrequently detected in surficial soils, subsurface soils, surficial sediments and subsurface sediment samples. No surface water or biota samples were analyzed for dioxins/furans.

- Area E – Dioxins/furans were frequently detected in surficial and subsurface sediment samples. No dioxins/furans were detected in the soils. No surface water or biota samples were analyzed for dioxins/furans.

8.1.7 Metals

Metals were identified contaminants in both sections of Area III, (Areas D and E).

8.1.7.1 Nature of Metals Contamination

Lead was the most prevalent Raymark-related metal detected at elevated levels within Area III. Lead is used in fabricating brake and friction products (such as were used at Raymark). Metals within Areas III appear to originate from Raymark waste, from the facility and filled areas, and from transport and deposition of the wastes from these locations.

8.1.7.2 Extent of Metals Contamination

- Area D – Metals were frequently detected in surficial and subsurface sediments (chromium and lead were the most frequent), surficial soils (copper, manganese, and lead), subsurface soils (arsenic, barium, cadmium, chromium and nickel) and biota. Metals were detected infrequently in the surface water (copper).

- Area E – Metals were frequently detected in surficial and subsurface sediments (arsenic and chromium) and surface water (arsenic and lead). Soil samples were analyzed for metals but did not exceed CT DEC standards. Biota samples were not collected in this area.

8.1.8 Asbestos

Asbestos was an identified contaminant in only one section of Area III, Area D.

8.1.8.1 Nature of Asbestos Contamination

Asbestos-containing materials were a primary component of products manufactured at the Raymark Facility. Asbestos fibers were mixed with phenolic resins to manufacture brake pads, linings, clutches, transmission plates, and gaskets.

8.1.8.2 Extent of Asbestos Contamination

- Area D – Asbestos was infrequently detected at greater than 1 percent in sediments and soils. No surface water samples or biota samples were analyzed for asbestos.

- Area E – Asbestos was not detected in sediments. Soil samples, biota, and surface water samples were not analyzed for asbestos.

8.2 Contaminant Fate and Transport Summary

Contaminant fate and transport in the environment are controlled by a number of factors: chemical and physical properties of the contaminants, geologic formations, hydrologic conditions, aquifer conductivity, topography, precipitation, and tidal flow.

The contaminants identified in the nature and extent discussion are associated with the former Raymark Facility. Major pathways of migration within Area III are wastewater and drainage discharge from the former Raymark Facility, transported via surface water in Ferry Creek; erosion and runoff from the former Raymark Facility to Ferry Creek and the Housatonic River; and erosion and runoff from the Raymark soil-waste/fill areas into the Housatonic River. Water flowing through this area has also eroded the banks where Raymark soil-waste/fill has been disposed within the Beacon Point area and the Elm Street wetland.

Wastewater and drainage discharge from the Raymark Facility were the principal contributors to contamination in Ferry Creek sediment and surface water. The discharges slowed when the Raymark Facility closed in 1989 and ceased after the closure of lagoon number 4 in 1995. The placement of the contaminated Raymark soil-waste/fill on properties within the Area I study area (TtNUS, 1999), the Area II study area (TtNUS 2000), and in the Area III study area are the predominant sources of soil contamination across Area III and is a continuing source of contamination to sediments and surface waters. The disposal of Raymark soil-waste/fill has resulted in the direct and indirect release of contamination into the surface water, sediments, biota, and soils within Area III.

8.3 Risk Assessment Summary

The risk assessment for this RI focused on human health and ecological risks.

8.3.1 Human Health Risk Assessment

The Human Health Risk Assessment identified PAHs; total PCBs; metals; dioxin/furans; pesticides, and asbestos as the primary potential contaminants of concern within Area III. These contaminants were selected based on their toxicity, occurrence within the study area, and existence at the Raymark Facility. See Table 8-2 for a summary of the potential that could result from exposure to Raymark soil-waste/fill.

8.3.1.1 Area D

In Area D, risks were evaluated for the frequent recreational user, the wetland/marsh receptor, and the commercial worker. The following risks were identified;

- Cancer risks for the current commercial worker and future commercial worker in Area D exceeded the target cancer risk range of 10^{-4} to 10^{-6}, and exceed the CT DEP target total risk level of 10^{-5} for the RME cases. The primary carcinogenic risk drivers are dioxins/furans, arsenic, PAHs {benzo(a)pyrene, benzo(a)anthracene, benzo(b) fluoranthene, dibenzo(a,h)anthracene, and indeno (1,2,3-cd)pyrene} and total Aroclors (PCBs). These contaminants have estimated cancer risks greater than the CT DEP target risk level of 10^{-6} for single contaminants. RME cancer risks for wetland/marsh receptors, and combined frequent adult and child recreational users are below the EPA target total risk range but exceed the CT DEP target total risk level of 10^{-5} and the CT DEP target risk level of 10^{-6} for single contaminants.

- Noncarcinogenic risks are possible for commercial workers and pre-adolescent wetland/marsh receptors exposed to Aroclors in soils and sediments in Area D.

- Asbestos poses a potential inhalation risk when migrating through the air. No quantitative risk estimates are available. Average asbestos concentration was 2 percent based on 141 samples.

- Lead exposure evaluation indicates that adverse effects from lead are anticipated for exposure to fetuses of pregnant commercial workers.

8.3.1.2 Area E

In Area E, risks were evaluated for adult and pre-adolescent wetland/marsh receptors. The following risks have been identified:

- Cancer risks for the combined adult and pre-adolescent wetland/marsh receptors and adult wetland/marsh receptors exceed the EPA target cancer risk range of 10^{-4} to 10^{-6} and exceed the CT DEP target total risk level of 10^{-5} for the RME cases. The primary carcinogenic risk drivers are total Aroclors, PAHs, and arsenic for soils and sediments. The primary carcinogen in surface water is total Aroclors. These contaminants have estimated cancer risks greater than the CT DEP target risk level of 10^{-6} for single contaminants.

- Noncarcinogenic risks are anticipated for the frequent recreational user based on total Aroclors in soils/sediments and surface waters.

8.3.2 Ecological Risk Evaluation

The Ecological Risk Assessment was conducted by NOAA; SAIC conducted a supplemental ecological investigation and analysis. TtNUS has summarized their assessments in Section 7.0, the full text of these documents are presented in Appendix D. To facilitate understanding of the results, see Table 8-2 for a summary of the potential risks that could result from exposure to Raymark-type waste.

8.3.2.1 Area D

In Area D the following risks were identified:

- Concentrations of copper, lead, mercury, nickel, silver, zinc, PCBs, and DDD in surface water at Area III may be harmful to fish and other forms of aquatic life.

- Relative to background, sediment levels with high levels of dioxins, PCBs, pesticides, lead, and copper appear to be the main contributors to potential risk. Although these contaminants are found in the sediment in both areas, the highest concentrations of dioxins, lead, and copper occur in Area D.

- Tissue concentrations of copper indicate potential risk to invertebrates.

- Sediment toxicity is moderate to severe for amphipods.

- Wildlife feeding in the aquatic environment will be at risk for exposure to lead, mercury, and zinc. This risk extends to fish-eating birds, especially for lead risks.

8.3.2.2 Area E

- Concentrations of copper, lead, mercury, nickel, silver, zinc, PCBs, and DDD in surface water at Area III may be harmful to fish and other forms of aquatic life.

- Relative to background, sediment levels with high levels of dioxins, PCBs, pesticides, lead, and copper appear to be the main contributors to potential risk. Although these contaminants are found in the sediment in both areas, the highest values for PCBs and pesticides occur in Area E.

- Sediment toxicity is low for amphipods.

- Wildlife feeding in Area E is assumed to have risks from mercury and PCBs.

8.4 Conclusions

The interpretation of the data and information compiled for this RI indicates that:

- Raymark Facility soil-waste/fill was disposed of as fill throughout Area III.

- Fill and natural soils throughout Area III are contaminated with asbestos, metals, pesticides, SVOCs, PCBs, and dioxins. In some areas, the level of contamination is high.

- Analysis of soil, sediment, biota and surface water samples reveals that there is widespread contamination. Although contamination is ubiquitous, the contaminants and concentrations are not distributed evenly across Area III (because of irregular dumping patterns and contaminant transport variables).

- Contamination is widespread throughout Area III, therefore there is potential risk to human health from Raymark soil-waste/fill throughout Area III.

- There are ecological impacts from the widespread contamination throughout Area III.

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